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DEVICES FOR SUPPLYING FUEL TO FUEL CELLS
[Vorrichtungen zur Brennstoffversorgung von Brennstoffzellen]

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This invention relates to devices for supply of fuel cell systems with fuel. In particular the invention relates to fuel cartridges for fuel cell systems and devices in order to ensure reliable and controllable supply of fuel from the fuel cartridges to the fuel cell systems. /1*

Prior Art

In those applications in which the fuel cell has clear advantages over disposable batteries or rechargeable batteries, the classical processes of power supply independently of the grid are also often preferred over a fuel cell. The reasons are often not that the corresponding technology would be more advantageous or sophisticated, but that the used batteries can be easily replaced by new batteries, empty rechargeable batteries can be easily recharged and moreover in many applications rechargeable and/or disposable batteries can be optionally used.

(Continuous) power supply with a fuel cell requires (continuous) supply of the fuel cell with fuel. Here it is conventional to supply the fuel with consideration of individual aspects; this is comparatively complex and ineffective on the one hand, and on the other results in that the different approaches for different applications are often incompatible with one another. Fuel cells used in the field of so-called consumer electronics comprise generally an integrated fuel tank with a fuel store which is sufficient for operation of up to several hours. When the store is used up, the fuel tank must be refilled; this is relatively complex. Generally the operation of the

* Numbers in the margin indicate pagination in the foreign text.

fuel cell must be interrupted and strict safety regulations must be observed.

Thus the object of the invention is to eliminate the /2 disadvantages which exist in supplying power with fuel cells and especially to improve the fuel supply of fuel cells.

Description of the Invention

To achieve this object a fuel cartridge and a cartridge housing device for the fuel cartridge are prepared. Furthermore the invention makes available devices for metering of the fuel flow out of a fuel cartridge which has been inserted in the cartridge housing device.

According to a first aspect of this invention a fuel cartridge for supplying a fuel cell device is made available which has an outlet means which is made such that it can be opened by an opening device of a cartridge housing device which corresponds to the fuel cartridge.

According to a second aspect of this invention a cartridge housing device for such a fuel cartridge is made available which has guide and retaining means for guiding/retaining the fuel cartridges, opening means for opening the fuel cartridges, and fuel extraction devices for extracting fuel from the fuel cartridge.

The fuel cartridges as claimed in the invention can be used both for refilling a fuel tank of a fuel cell device and also directly as a tank cartridge for operating a fuel cell device. Replacement of am empty fuel cartridge by a full fuel cartridge requires only a few manipulations and can be done as quickly as changing a battery. The outlet means of the fuel cartridge is made such that when used properly it can only be opened in the corresponding cartridge housing device. The outlet means/opening means interface between the cartridge and the

cartridge housing device is made fluid-tight, so that hazards due to accidently emerging fuel can be largely precluded.

In one preferred development the fuel cartridge and/or the cartridge housing device comprises a means to pressurize the fuel in the fuel chamber of the fuel cartridge. /3

In this case the fuel flows through the opened outlet opening without the necessity of actively pumping out the fuel by a pump which is to be placed in the fuel line of the fuel cell. This enables the entire system to be made smaller.

In advantageous developments of the fuel cartridge and/or the cartridge housing device the pressurizing means comprise a gas.

Thus the fuel in the fuel cartridge can be pressurized by a compressed gas which is provided within the cartridge. In this case an installation-ready, filled fuel cartridge is under pressure. Alternatively unpressurized fuel cartridges can be made available in which the fuel is pressurized only after installation in the cartridge housing device. In certain applications these unpressurized fuel cartridges can be preferable to pressurized cartridges for reasons of safety. The pressurization of the fuel can be accomplished by gas generating cells in both cases. Among others, CO_2-based pressurized gas cartridges can be used.

In one especially preferred development the pressurizing device has a compression spring.

Compression springs constitute a simple, economical means which is little susceptible to external effects (especially temperature and pressure fluctuations) for pressurization. They act on at least one movable or expandable wall of a fuel reservoir, or on a piston which

extends into the fuel chamber. They can be provided both within the cartridge, and can also be a component of the cartridge housing device.

Especially with respect to the use of unpressurized fuel cartridges, the pressurization devices preferably comprise devices which make it possible to pressurize the fuel in the fuel cartridge by /4
applying an external force.

Fuel is extracted through the outlet means of the fuel cartridge. The outlet means can be for example a hole or another recess in the cartridge housing. In the simplest case the outlet means is formed by a predetermined region of the cartridge housing which is punctured when the cartridge is opened. To facilitate the opening process this region can be premolded accordingly, for example by a depression for guiding the opening means.

In most developments the outlet means is little suited solely to reclosing the cartridge once it has been opened, so that in advantageous developments it has a closing means which closes the outlet means of the cartridge and which enables repeated opening and closing of the fuel cartridge. Preferably this closing means comprises a nonreturn valve.

This closing means facilitates safe handling of already opened fuel cartridges and makes it possible for partially emptied cartridges to be safely removed from the cartridge housing device, for example in order to replace them by full cartridges.

In the fuel cartridges as claimed in the invention there can be especially preferably with respect to the latter aspect, but also in other developments quite advantageously, a fill level indicator which indicates the fuel fill state of the cartridge.

This allows simple monitoring of the consumption and thus prompt recognition of operating conditions, especially of deviations from ideal operating conditions, and prompt resupply.

In one especially preferred development of the invention the fuel cartridge and/or the cartridge housing device comprises/ comprise a metering means in order to control the flow of fuel out of the cartridge.

For this reason the fuel flow can be easily matched to the /5
altered requirements, for example due to variable operating conditions. In particular several metering means can be used which are designed for coarse and fine metering.

In one advantageous development the metering means comprises a pump means since in this way metering can be controlled directly and actively by way of the flow rates of the pump means.

Micropumps are the preferred versions of pump means especially for compact and miniaturized applications of fuel cells; they can be easily triggered, are accurate and economical, and require extremely little space so that they can be installed almost anywhere.

In one advantageous development the metering means comprises at least one activatable valve.

Especially for these combinations of cartridges and cartridge housing devices in which the fuel is delivered by an overpressure, these valves constitute a simple and precise possibility for controlling the fuel flow.

Preferably at least one valve can be magnetically or piezoelectrically actuated since this enables prompt activation, but is high-precision and mechanically of low complexity.

Depending on the order of magnitude of the desired flow rates, the fuel properties such as viscosity, and other fluid-mechanical or control-specific aspects, at least one valve can be a needle valve or a disk valve and/or a slide valve.

The described cartridges are especially well suited for safe transport and safe storage of fuel, and for safe extraction of fuel by correspondingly made cartridge housing devices. Thus the fuel cartridges as claimed in the invention can be advantageously used /6
directly as refill cartridges and/or as tank cartridges in fuel cell devices, when they are equipped with these cartridge housing devices.

In the former case they allow the fuel tank of a fuel cell device to be filled easily and reliably.

In the latter and especially preferred case, specifically in use as a tank cartridge, there is the possibility of designing compact embodiments of fuel cell devices in which the fuel cartridge continuously supplies the fuel cell device with fuel during operation.

With respect to the hazard potential of fuels used for fuel cells, developments of the fuel cartridge as claimed in the invention are preferred, which either entirely preclude or make difficult the repeated use of a fuel cartridge and make it dependent on safety checking by qualified personal. For this purpose the cartridge has a safety means which is damaged in the process of insertion into the cartridge housing device and/or in the process of extraction from the cartridge housing device. Here the damage can be reversible or irreversible; repair or replacement of damaged parts however if at all should be possible only by qualified specialists or for individuals not

specially authorized to do so it should be associated with unduly great effort.

The safety means can be made such that damage makes refilling of the cartridge entirely impossible. Similarly to camping gas cartridges, this can be achieved for example by a perforation which is to be made in the insertion process in the outlet region of the cartridge so that only the combination of the cartridge housing device including the inserted cartridge is tight to the outside, but not the cartridge alone.

Alternatively the safety means can have elements which are broken off or damaged, for example bent, when the cartridge is inserted and/or removed such that they make re-insertion of the cartridge into the cartridge housing device and/or refilling of the cartridges dependent on the replacement of the damaged elements by undamaged elements. Advantageously these elements are made so complex that they cannot be /7
copied or repaired for a layman or only with comparatively high cost. Further safety can be obtained by the replacement process requiring a device especially intended for this purpose.

The cartridge housing device as claimed in the invention in especially advantageous developments has retaining means (such as lock elements, compression springs, etc.) and/or guide devices (such as guide rails, centering elements, etc.) which all ensure and contribute to the interface between the outlet means of the cartridges and the opening means of the cartridge housing device being made to seal in a reliable and reproducible manner.

According to one further aspect of this invention a fuel cell device with at least one cartridge housing device as described above is made available.

These fuel cell devices can be operated directly with the cartridges as claimed in the invention without the necessity of construction changes. For two (or more) cartridge housing devices it is accordingly possible to insert in parallel two (or more) fuel cartridges which are preferably emptied in succession so that operation of the fuel cell device during replacement of one fuel cartridge can be maintained.

For further explanation, preferred embodiments of this invention are described below with reference to the attached figures.

Figure 1 shows in a schematic view a fuel cartridge as claimed in the invention, a cartridge housing device as claimed in the invention, and common use of both

Figure 2 shows the use of a metering means with the devices as claimed in the invention from Figure 1

Figure 3 shows a first embodiment for a fuel cartridge as claimed /8
in this invention

Figure 4 shows a second embodiment for a fuel cartridge as claimed in the invention

Figure 5 shows a third embodiment for a fuel cartridge as claimed in the invention

Figure 6 shows a fourth embodiment for a fuel cartridge as claimed in the invention

Figure 7 shows a fifth embodiment for a fuel cartridge as claimed in the invention

Figure 8 shows a sixth embodiment for a fuel cartridge as claimed in the invention

Figure 9 shows a first embodiment for execution of an interface between the cartridge as claimed in the invention and the cartridge housing device as claimed in the invention

Figure 10 shows a second embodiment for execution of such an interface

Figure 11 shows a third embodiment for execution of such an interface

Figure 12 shows a first preferred embodiment of a metering means

Figure 13 shows a second preferred embodiment of a metering means

Figure 14 shows a housing with compartments for devices for operating a fuel cell system, including a cartridge compartment

Figure 15 shows a fuel cartridge which has been inserted into the housing from Figure 14.

Highly schematized Figures 1 and 2 serve to illustrate some /9
underlying principles of this invention.

Figure 1(i) shows a fuel cartridge 1 with an outlet region 1a via which the fuel is extracted from the cartridge 1.

Figure 1(ii) shows a cartridge housing device 2 for the fuel cartridge 1 shown in Figure 1(i).

The housing device 2 has retaining means 2c which are used for safe and stable positioning of a fuel cartridge 1 which has been inserted into the housing device 2. Simple but still reliable versions of these retaining means 2c comprise for example spring-mounted retaining hooks or helical springs.

Furthermore the housing device 2 has a connecting means 2b which is used to produce a connection which is fluid-tight relative to the surroundings, especially with reference to the fuel used, between the outlet 1a of the cartridge 1 and a fuel extraction means 2 (for example a pipeline) which leads away from the housing device 2. The connecting means 2b can comprise for example a coupling means with a flange (including seals) which is matched to the outlet region of the cartridge. In especially preferred embodiments this connecting means 2b is also used to open the fuel cartridge. One simple example of this is a hollow needle which penetrates the outlet region 1a of the cartridge 1 when the cartridge 1 is inserted or locked into the housing device 2 and thus produces a fluid connection between the fuel reservoir in the cartridge 1 and the fuel line 2a which leads away from the housing device 2.

Preferably both the cartridge housing device 2 and also the fuel cartridge 1 have guide means and centering means (not shown) which are matched to one another and which are used for insertion and precise positioning of the fuel cartridge 1 in the housing device 2. If the cartridge has a safety means which is to damaged in the process of insertion into the cartridge housing device and/or in the process of extraction from the cartridge housing device, depending on the execution of this safety means, for this purpose there can be special /10
means in the cartridge housing device 2 which cause this damage. Alternatively this damage can however also be accomplished by way of the aforementioned guide means and centering means or standard means such as the opening means 2b.

Figure 1(iii) shows the cartridge housing device 2 from Figure 1(ii) together with an inserted fuel cartridge from Figure 1(i). In the state shown in Figure 1(iii) the fuel from the fuel cartridge 1 can be extracted by way of a fuel line 2a.

For controlled operation of a fuel cell system precise metering of the supplied fuel flow is necessary.

Proceeding from Figure 1(iii) this metering can take place as illustrated in Figure 2(iii):

As shown in Figure 2(iii), the fuel which has been extracted by way of the fuel line 2a from the fuel cartridge passes through a metering device 3 which controls the flow of fuel supplied to the fuel cell system.

Alternative possibilities of arrangement for a metering means 3 are shown in Figures 2(i) and 2(ii).

Figure 2(i) shows a fuel cartridge 1 with an integrated metering means 3. For this purpose the possibilities are the following: a) the metering means 3 is located completely within the housing of the fuel cartridge 1, therefore in front of the actual outlet 1a (left part of the figure); b) the metering means 3 is integrated into the outlet means 1a of the fuel cartridge 1 or is seated directly on the outlet means 1a of the fuel cartridge 1 (right part of the figure). For these versions of course the housing device must be adapted accordingly.

In the following figures, for features with the same or equivalent correspondence the same reference numbers or those increased by 100 each time are used. A detailed discussion of functional properties of these structurally and/or functionally comparable features is omitted /11

if this would lead simply to repetition of the circumstance already described in detail in conjunction with preceding figures.

Figure 3 shows a first embodiment for a fuel cartridge 1 according to this invention.

The cartridge 1 has an outside housing 1b of stable shape which on one end has a closing means 311 which closes the outlet 1a. Within the housing 1b there is an inner envelope 312 which runs parallel to the lengthwise axis of the housing 1b and which is connected fluid-tight (i.e. gas-tight and/or fluid-tight) to the outlet-side end inner surface and the end inner surface of the housing opposite the outlet side. In this case the inner envelope 312 is made as a bellows (for example from an elastomer). The interior of the cartridge 1 is divided into a fuel chamber 1c and a second chamber 313 which in this embodiment is filled with a pressurized gas. The fuel chamber 1c is separated from the gas chamber 313 by a partition 314 which is welded to the bellows 312 and which extends perpendicular to the lengthwise axis of the cartridge. The bellows 312 likewise prevents mixing of the compressed gas and the fuel.

Since the partition 314 is held only by the elastomer, but can move freely along the lengthwise direction of the housing 1b, accordingly the fuel in the fuel chamber 1c is also exposed to essentially the same pressure as the gas. Thus, opening of the closing means 311 to the outlet opening 1a causes the fuel to be displaced by it out of the cartridge 1.

In the illustrated embodiment the gas in the gas chamber 313 has a given initial pressure which decreases with emptying of the cartridge. Alternatively the end of the housing 1b which closes the gas chamber

can be provided with a gas connection and a nonreturn valve in order to resupply gas parallel to emptying the cartridge 1 and thus to set the gas pressure in the gas chamber to a constant or variable value.

The type of materials which are used for the cartridge 1 depends /12 largely on the chemical properties of the fuel, but also on the areas of application of the fuel cell. A metal outer housing 1b is mechanically and thermally more stable than a plastic housing. As a result of the higher material strength higher internal pressures can be used. For the same outside dimensions a greater internal volume can be achieved. Conversely plastics have a weight advantage and are of more stable shape relative to moderate external forces.

Especially for methanol as the fuel must it be watched that most plastics in contrast to metals have a not negligible, in part eve high permeability to methanol. When using the fuel methanol therefore the outside housing 1b of the described fuel cartridges 1 is preferably produced using metallic materials. Both completely metal housings but also the use of metal-containing composites and/or metal coated materials are possible.

Figure 4 shows another embodiment for a fuel cartridge as claimed in the invention. The parts corresponding to Figure 3 are described below only to the extent they have differences from the embodiment which is shown in Figure 3.

The cartridge 1 on the outlet side has a fuel chamber 1c which is isolated from the housing interior by a bellows 412 and a partition 414, the latter being connected securely to the free end of the bellows 412. The outlet-side end of the bellows 412 is connected permanently to the inside wall of the housing 1b as in the embodiment from Figure 3.

In contrast to Figure 3, the bellows 412 does not extend along the entire lengthwise direction of the housing 451 here and is fixed only on the inside of the housing 1b on the outlet side.

While in the embodiment from Figure 3 a pressurized gas delivers the energy which is required for displacement of the fuel, for this purpose in the embodiment from Figure 4 a helical spring 415 is used which is provided between one housing end and the partition 414 in the pretensioned state.

The outlet opening 1a is closed by a nonreturn valve 411 which /13
can be opened by an external device which can be introduced along the outlet opening 1a. In order to achieve a degree of emptying as high as possible, the partition 414 has a center bulge which extends in the shape of a piston into the helical spring 415 and which prevents the partition 414 from coming into contact with the nonreturn valve 411.

Another embodiment for a fuel cartridge as claimed in the invention is shown in Figure 5.

The fuel cartridge 1 from Figure 5 has a double jacket similarly to the one from Figure 3. The outer jacket is formed by the outside housing 1b and imparts mechanical stability to the cartridge, while the inner jacket 512 defines the actual fuel chamber 1c.

The inner jacket 512 is in turn securely connected on the outlet side to the inside of the housing 1b and can move freely along the housing axis on the opposing housing end. The fuel chamber 1c can be emptied in the direction of the outlet 1a by opening the closing means 511. The inner jacket 512 is made elastic such that it tends to collapse. This property of the inner jacket is achieved by its being formed either completely of an elastic material, or as a bellows of a

more or less elastic cladding material in conjunction with an element which imparts elasticity. In this example a stretched helical spring is injected into the bellows. In this way a pressure is applied to the fuel within the fuel chamber 1c; this causes the fuel to be displaced through the outlet opening 1a when the cartridge 1 is opened.

Since when the cartridge 1 is emptied the volume of the fuel chamber 1c decreases, a vacuum must be prevented from forming between the inner and outer jacket which would hinder complete emptying. For this purpose, in the wall of the outer envelope 1b there is an opening 516 which enables pressure equalization with the vicinity. In order to ensure for possible damage of the inner jacket 512 that fuel cannot emerge through the opening 516, it is advantageous to provide this opening 516 with a nonreturn valve (not shown). This is mainly also necessary when the fuel has toxic or chemically corrosive properties /14
and can diffuse through the wall of the fuel chamber 515.

The cartridges shown in Figures 3 to 5 are according to an active type in which the action required for emptying is applied by devices of the cartridge 1, in the illustrated embodiments the action being accomplished by pressurization.

Figure 6 shows a "passive" fuel cartridge 1, i.e., a cartridge in which opening of the closing means 611 does not cause automatic self-emptying of the cartridge 1. Moreover this fuel cartridge 1 represents one embodiment of the type shown in the left part of Figure 2(i) in which important components of the metering means 3 are integrated into the fuel cartridge 1.

A peristaltic pump impeller 617 is integrated into the cartridge 1 and is provided between the actual fuel chamber 1c and the outlet 1a.

Emptying takes place by turning the pump impeller 617 and is supported by gravity acting on the liquid fuel. Therefore the advantageous operating position of the cartridge 1 shown in Figure 6 is vertical with the outlet 1a down. Preferably the motor for driving the pump impeller 617 is not a component of the cartridge 1, but is integrated into the cartridge housing device 2 for the cartridge 1.

The fuel itself is located within a bag 612 which extends as far as the outlet 1c of the cartridge 1. In the peripheral region of the pump impeller 617 the bag 612 tapers to a hose, and the hose diameter can be changed by the movable slide 618.

By turning the pump impeller 660 counterclockwise, successive amounts of liquid of predetermined volumes can be displaced from the fuel chamber 1c into the hose region and delivered to the outside on the outlet opening 1a which is provided with a lip 611.

Metering of the fuel flow, i.e., control of the volumetric flow /15
which is delivered through the outlet opening 1a, can take place for example directly by way of control of the rotational speed of the pump impeller 617. In this case the hose diameter could be fixed to a predetermined value and the movable slide 618 can be omitted. Alternatively, the pump impeller 617 can be driven with a rotational velocity which is constant in the ideal case, the volumetric flow being controlled essentially by variation of the hose diameter by way of moving the slide 618. But it is also possible for the movement of the slide 618 to apply a not negligible contact pressure to the pump impeller, which causes a reduction of the rotational speed of the pump impeller 617. This must be considered in the control of metering of the volumetric flow which is to be conveyed.

The above described embodiment of the cartridge 1 is more complex than the one shown in Figures 3 to 5. But it has the advantage that simple metering of the volumetric flow is possible and a separate metering means 3 is not necessary. Another advantage which is not immediately apparent due to the figure's not being to scale is that by far the largest portion of the inside volume can be used to store fuel.

Another embodiment of a passive fuel cartridge is shown in Figure 7 which moreover constitutes one embodiment of the type sketched in Figure 2(ii), in which important components of the metering means 3 are integrated into the cartridge housing device 2.

The fuel cartridge 1 from Figure 7 is inserted into the cartridge housing device 2. Similarly to the cartridge from Figure 4, this cartridge has a piston surface 714 which can be moved freely along the lengthwise axis of the cartridge and which defines the fuel chamber 1c together with a roll membrane 712 which is attached to the inside of the outlet of the cartridge housing. In the fully filled state the piston surface 714 is essentially on the side of the housing opposite the outlet. By applying a force pointed in the direction of the outlet to the piston surface 714 the pressure required to extract the fuel is applied to the liquid fuel which is provided in the fuel chamber 1c.

In the illustrated embodiment the force is applied to the /16
outside of the piston essentially by a disk spring stack 731. To control the piston motion and thus metering of the fuel flow from the fuel cell 1, between the disk spring stack 731 and the piston surface 714 there is a double spindle 732 which is triggered by a stepping motor which is not shown.

Figure 8 shows relevant parts of another embodiment of a fuel cartridge and a corresponding cartridge housing device. Of the cartridge housing device, only those features which are used for pressurizing the cartridge is shown.

The cartridge 1 has two movable pistons 814 and 815 which are spaced by a helical spring 815 which is permanently connected to the piston. The axis of the helical spring is aligned essentially with the housing axis.

For free cartridges and also in the illustrated state the helical spring 815 is relieved or is only slightly pretensioned so that the fuel in the fuel chamber 1c is under negligible pressure.

The housing device for the cartridge 1 has a cam 821 which can be turned around the pivot 823 by means of a handle 822. When the cartridge 1 has been inserted and the handle 822 has been actuated, as the cam 821 turns the piston surface 824 is pushed in the direction of the piston surface 814, the helical spring being compressed, by which in turn a pressure is applied to the fuel which is located in the fuel chamber 1c.

In the following Figures 9 to 12 different preferred embodiments are described for the implementation of an interface which is used for extracting fuel between the fuel cartridge 1 and the fuel extraction devices (compare Figure 1).

One fundamental distinguishing feature for a cartridge which lies within the scope of this invention is the type of interface via which emptying of the cartridge takes place:

Here the cartridge-side interface can be made such that it is /17

irreversibly damaged in the insertion process, for example by perforation of the housing (similarly to gas cartridges used in the camping domain).

Alternatively this interface - as shown in Figures 9A and 9B -can have a septum 911 which is punctured when inserted through the needle tip 2b. Based on the elastic properties of the septum the cartridge is reclosed after the needle is retracted so that the septum represents a quasi-reversible closing means.

The interfaces which are described in conjunction with Figures 10 to 12 are conversely not damaged in the emptying process and are therefore preferred for reusable cartridges. With these cartridges it is also more easily possible to interrupt the emptying process and to extract the cartridge from the cartridge housing device when it has been only partially emptied.

Figures 9A and 9B show a first preferred embodiment of an interface.

Figure 9A shows the start of the process of insertion of the cartridge 1 into the cartridge housing device 2.

The outlet region 1a of the cartridge 1 has a septum 911 which is held by a retaining device which is connected securely to the housing 1b. Within the septum 911, centrally there is recess for better guidance of a hollow needle 2b which punctures the septum.

In the situation shown in Figure 9B the insertion process is completed. Here the hollow needle 2b has punctured the septum 911 and has penetrated into the cartridge 1 so far that the needle opening extends into the fuel tank 1c so that the fuel can be extracted by way of the hollow needle.

The fuel which has been extracted by way of the needle 2b flows out of the end of the needle 2b which faces away from the cartridge into the fuel extraction device 2a which can for example comprise filter means 925 and an intermediate storage 926, from which the fuel can be supplied to the fuel cell device by way of an interposed /18 metering unit 3 (compare Figure 2).

The cartridge 1 which is shown in Figures 9 is characterized in that the septum 911 which closes the cartridge in the original state is punctured by puncturing with the needle 2b, i.e. it is irreversibly damaged, but has elastic properties so that the cartridge 1 is closed again after the needle 2b has been retracted. Accordingly a cartridge formed in this way after completed installation need not necessarily be emptied, but due to these quasi-reversible properties of the septum can be extracted even in the partially emptied state without safety concerns.

Conversely, Figures 10 and 11 show one embodiment of the cartridge 1 which have a completely reversible opening mechanism and are thus more flexible than the cartridge from Figure 9, but at the same time have a somewhat more complex structure.

The fuel cartridge 1 from Figure 10 on the cartridge head has an outlet means 1a with a lengthwise hole which extends into the interior of the cartridge. Perpendicular to the lengthwise hole there is a lateral fuel channel 1019 which communicates with the fuel chamber. At the height of the channel 1019 in the lengthwise hole there is a sleeve 1011 on which a spring acts and which blocks the side channel 1019. The sleeve 1011 can be moved opposite the spring force in the direction of the opposite housing end so far that the side channel 1019 is cleared

so that fuel can flow out of the fuel chamber 1c into the lengthwise channel.

Figure 10B schematically illustrates the device which is used for emptying the fuel cartridge. For this purpose there is a piston 2b whose shape and dimensioning are matched to those of the outlet region 1a of the fuel cartridge 1. Like the needle described in conjunction with Figure 9, this piston 2b is hollow to the inside, the hollow needle formed in the piston being used for fuel extraction. When the piston 2b is inserted into the outlet region 1a of the fuel cartridge 1, the end region of the piston comes into contact with the sleeve 1011 and as insertion continues causes the sleeve 1011 to be pushed against the action of the spring.

In the illustrated state, finally the sleeve 1011 is pushed so /19
far that the hollow needle of the piston is in fluid communication with the fuel chamber 1c so that the fuel can be extracted.

Figures 11A and 11B show a sectional view of the outlet region 1a of a fuel cartridge 1, and the corresponding sectional view of parts of the fuel extraction devices.

In the fuel cartridge 1, as in the cartridge from Figure 10, there is a lateral outlet channel 1119 which however in contrast thereto is not closed by a movable part (in Figure 10: sleeve 1011) but by a rotary blocking part 1111. This blocking part 1111 has a hole which can be moved in alignment with the lateral outlet channel 1119 by turning the blocking part 1111.

To turn the blocking part 1111 there is a connecting means 2b which can be placed from the outside in the lengthwise hole of the outlet 1a in the form of a T-shaped key which can be caused to engage

the blocking part. The element of the key 2b which corresponds to the crossbar of the "T" has a continuous channel 1127. The vertical bar of the "T" constitutes a handle 1122 for turning the key 2b.

Turning of the key 2b by actuating the handle 1122 causes rotation of the blocking part 1111 and opening of the cartridge as soon as the hole of the blocking part 1111 and the outlet channel are aligned with one another.

On the side of this T-piece facing the fuel line 2a, for safeguarding and as a backstop there can be another blocking part 1128 which is opened simultaneously with the blocking part 1111 by turning the key 2b.

Figures 12 and 13 show two preferred embodiments of metering means 3 according to the principles of Figures 2(ii, iii) which are directly connected to the connecting means 2b which causes opening of the fuel cartridge. These metering means 3 have a valve 3a which can be actuated by way of a magnet coil 1233 (Figure 12) or by way of a piezoelement 1333 (Figure 13). In these examples the valve 3a is made as a disk /20
valve.

Instead of the disk valve, alternatively needle valves, membrane valves, slide valves, etc. can be used. Furthermore the metering device can also comprise pump means, especially micropumps.

Figures 14A, 14B and 15 schematically show an advantageous subdivision of a housing G matched to one another, which housing for accommodation of devices of this invention which are used for fuel supply of a fuel cell is set up together with the fuel cell.

Here Figures 14A and 15B show a back and front view of the empty housing G which in the preferred embodiment is divided into three

parts, and the compartments for all the devices necessary for operating a fuel cell device - including the fuel cell itself - can be accommodated within the housing. Reference GF labels the compartment for holding the fuel cell device, GD the compartment for holding a metering device, and 2 the compartment for holding a fuel cartridge. For the sake of simplicity means such as fuel lines, etc. are not shown.

Figure 14A shows a cylindrical recess 2A with a hole through the rear wall of the fuel cartridge compartment 2, the hole being made such that it corresponds to the outlet of an inserted fuel cartridge as claimed in the invention. This recess can also be used for example as a intermediate storage which is connected between the fuel cartridge and the metering unit. It goes without saying that the division into three parts is only exemplary and does not require any inventiveness at all, other divisions instead of the one shown can be used.

As the front view of the housing G in Figure 14B shows, the cartridge compartment 2 can have different elements which are used for insertion, exact guidance and retention of the fuel cartridge:

- guide ribs R which correspond to the appropriate depressions in the /21
outside wall of the cartridge ensure precise guidance of the cartridge and minimize lateral deviations (play perpendicular to the lengthwise axis of the cartridge);
- helical springs (which are sketched in Figure 2 and in the following Fig. 15) which are held by the spring guides FF in combination with a locking hook H provide for the inserted cartridge to be held reliably and without play along the lengthwise axis of the cartridge.

Figure 15 finally shows a skeletal view of the housing illustrated in Figures 14 with the fuel cartridge 1 inserted.

The two springs 2c - depending on feasibility - can be provided on the outlet-side outer surface of the fuel cartridge 1 or preferably on the spring guides FF shown in Figure 14B.

For the above described embodiments there was no separate fuel tank. In these cases the fuel cartridge is used directly as a tank cartridge which is gradually emptied when the fuel cell is being operated.

Alternatively the fuel cartridge can act as a refill cartridge which is emptied preferably in one pull in order to fill a separate fuel tank. Since in this case fine metering of the fuel flow is not necessary for emptying the cartridge, fuel cartridges for these applications can generally be made more simply than the above described tank cartridges. Another advantage of this version is that the fuel cell device can be operated without interruption since replacement of the fuel cartridge is not associated with interruption of the fuel supply.

In the case of use as a tank cartridge, uninterrupted operation of the fuel cell device is possible when there is an intermediate storage which contains enough fuel reserve to continue to operate the fuel cell device for the time interval which is necessary for replacing the tank cartridge. This intermediate storage is preferably integrated into the housing device for the fuel cartridge. Alternatively, uninterrupted operation of the fuel cell device is also possible even without such /22
a intermediate storage when the fuel cell device is made such that at least two fuel cartridges can be connected in parallel.

Claims /23

1. Fuel cartridge (1) for supply of a fuel cell device, with an outlet means (1) which is made such that it can be opened by an opening means (2b) of a cartridge housing device (2) which corresponds to the fuel cartridge (10).

2. Fuel cartridge (1) as claimed in Claim 1, with a means (313, 314; 413, 414, 415; 515; 714; 814, 815, 824) in order to pressurize the fuel in a fuel chamber (1c) of the fuel cartridge (1).

3. Fuel cartridge (1) as claimed in Claim 2, in which the pressurization means comprises a gas (313).

4. Fuel cartridge (1) as claimed in Claim 2, in which the pressurization means comprises a compression spring (415; 515; 815).

5. Fuel cartridge (1) as claimed in one of Claims 2 to 4, in which the pressurization means comprises means (714; 814, 815, 824) for pressurization of the fuel in the fuel cartridge (1) by applying an external force.

6. Fuel cartridge (1) as claimed in one of the preceding claims, with a closing means (311, 411, 511, 611) which closes the outlet means (1a) of the cartridge (1) and which enables reversible opening and closing of the fuel cartridge.

7. Fuel cartridge (1) as claimed in one of the preceding claims, with a fill level indicator to display the fuel level of the cartridge (1).

8. Fuel cartridge (1) as claimed in one of the preceding claims, with a metering means (617, 618) to control the fuel flow from the cartridge (1).

9. Fuel cartridge (1) as claimed in Claim 8, wherein the metering /24

means comprises a pump means (617).

10. Fuel cartridge (1) as claimed in Claim 9, wherein the pump means (617) comprises a micropump.

11. Fuel cartridge (1) as claimed in one of Claims 8 to 10, wherein the metering means comprises at least one activatable valve.

12. Fuel cartridge (1) as claimed in Claim 11, wherein at least one valve can be actuated magnetically or piezoelectrically.

13. Fuel cartridge (1) as claimed in Claim 11, wherein that at least one valve comprises a needle valve and/or a disk valve and/or a slide valve.

14. Fuel cartridge (1) as claimed in one of the preceding claims, for use as a refill cartridge for filling the fuel tank of the fuel cell device.

15. Fuel cartridge (1) as claimed in one of the preceding claims, for use as a tank cartridge.

16. Fuel cartridge (1) as claimed in one of the preceding claims with a safety means which is damaged in the process of insertion into the cartridge housing device (2) and/or in the process of extraction from the cartridge housing device (2).

17. Cartridge housing device (2) for a fuel cartridge (1) as claimed in one of the preceding claims, comprising:

guiding and retaining means (2c) for guiding/retaining the fuel cartridge (1);

opening means (2b) for opening the fuel cartridge (1); and

fuel extraction devices (2a) for extracting fuel from the fuel /25
cartridge (1).

18. Cartridge housing device (2) as claimed in Claim 17, with a means (731, 732; 821, 822, 823) in order to pressurize the fuel in a fuel chamber (1c) of the fuel cartridge (1).

19. Cartridge housing device (2) as claimed in Claim 18, in which the pressurizing means comprises a gas.

20. Cartridge housing device (2) as claimed in one of Claims 18 and 19, in which the pressurizing means comprises a compression spring (731).

21. Cartridge housing device (2) as claimed in one of Claims 17 to 20, in which the fuel extraction devices (2a) comprise a metering means (3).

22. Cartridge housing device (2) as claimed in Claim 21, wherein the metering means (3) comprises a pump means.

23. Cartridge housing device (2) as claimed in Claim 22, wherein the pump means comprises a micropump.

24. Cartridge housing device (2) as claimed in one of Claims 21 to 23, wherein the metering means (3) comprises at least one activatable valve (3a).

25. Cartridge housing device (2) as claimed in Claim 24, wherein at least one valve (3a) can be actuated magnetically or piezoelectrically.

26. Cartridge housing device (2) as claimed in Claim 25, wherein at least one valve comprises a needle valve and/or a disk valve and/or a slide valve.

27. Cartridge housing device (2) as claimed in one of Claims 17 to 26, in which the guiding and retaining means (2c) comprise at least one

locking element and/or at least one compression spring and/or at least one guide rail and/or at least one centering element.

28. Fuel cell device with at least one cartridge housing device (2) as claimed in one of Claims 17 to 27.

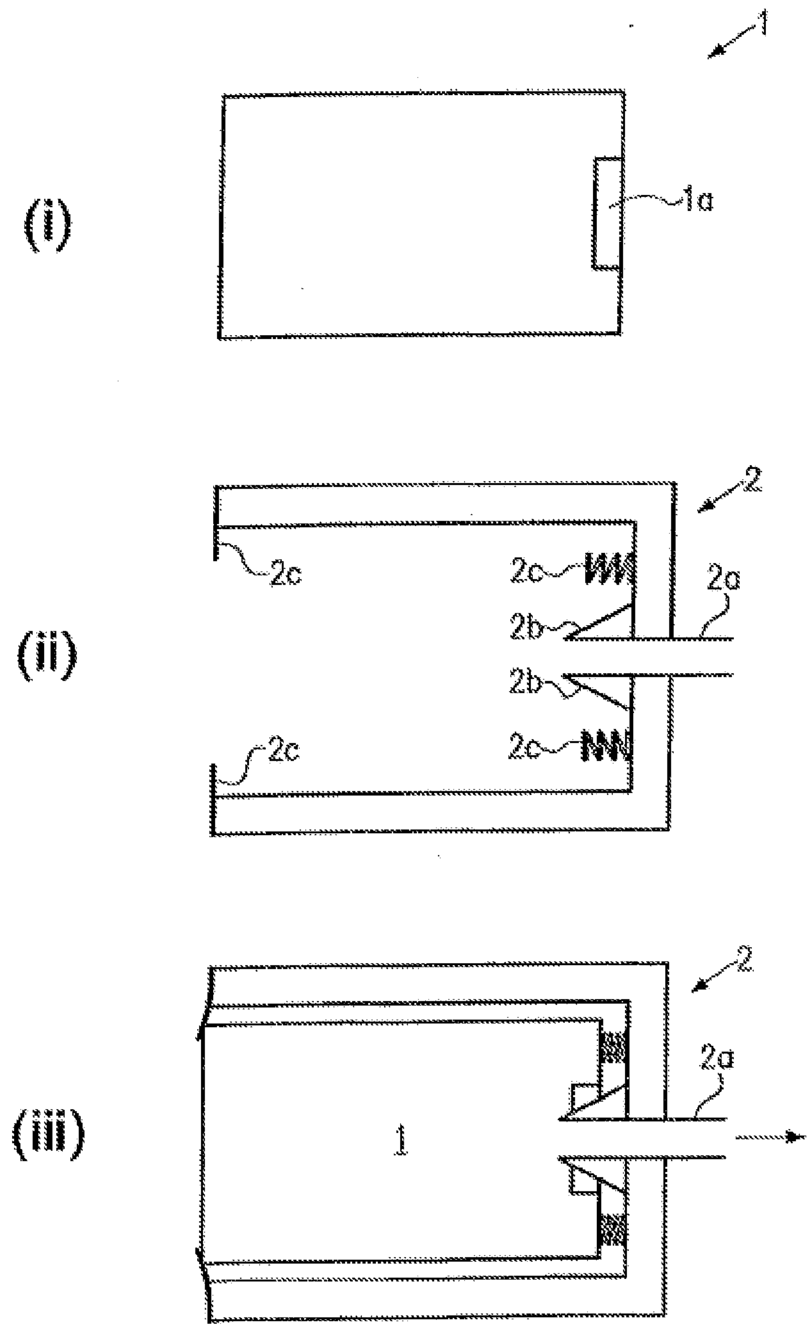

FIG. 1

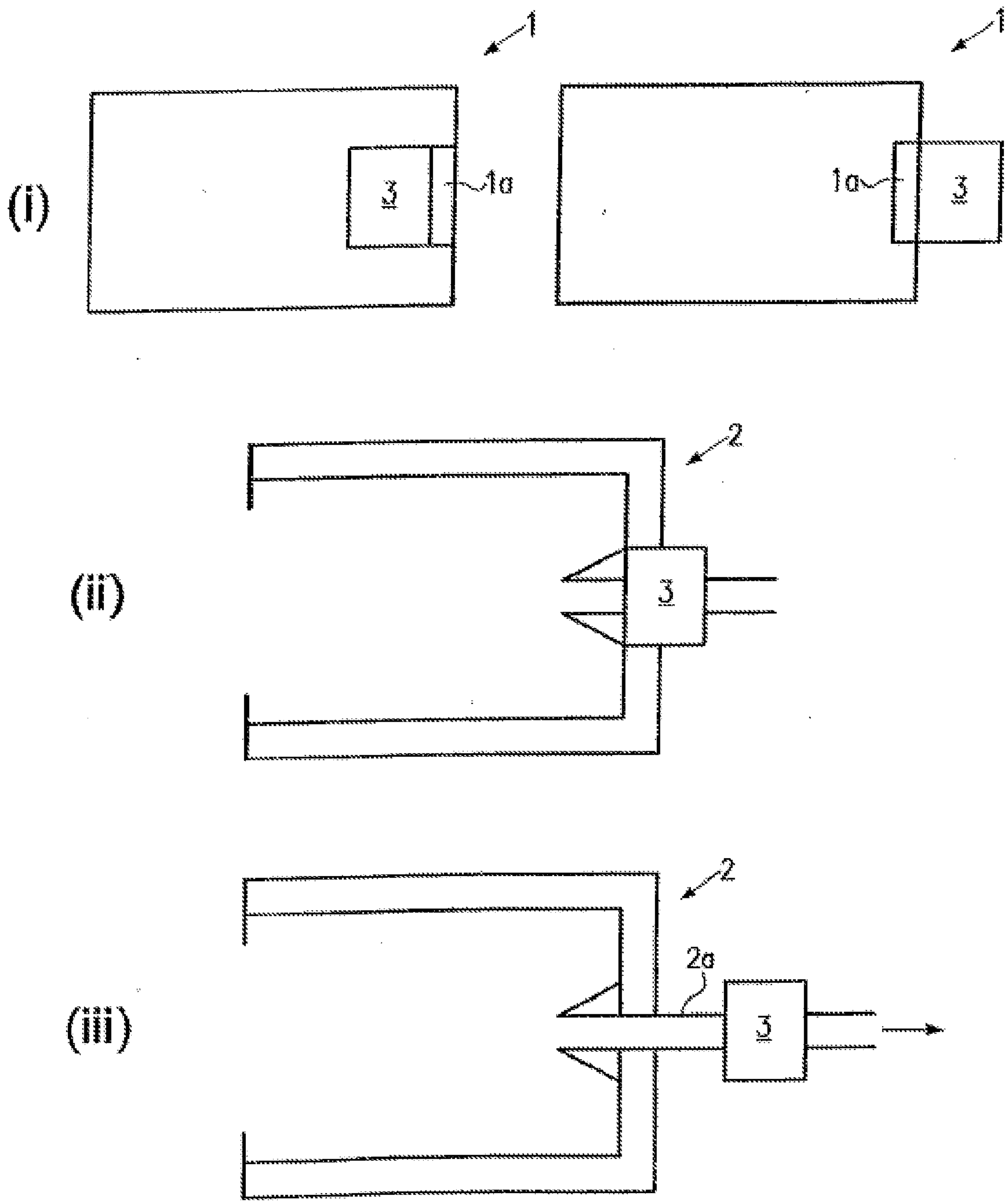

FIG. 2

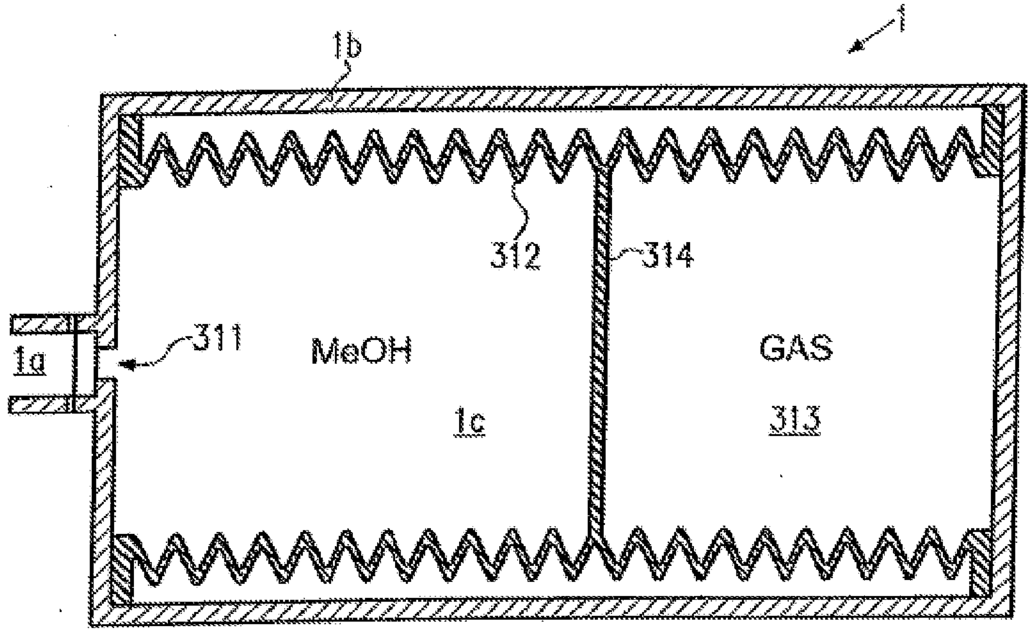
1
1b
312
314
1a
311
MeOH
GAS
1c
313

FIG. 3

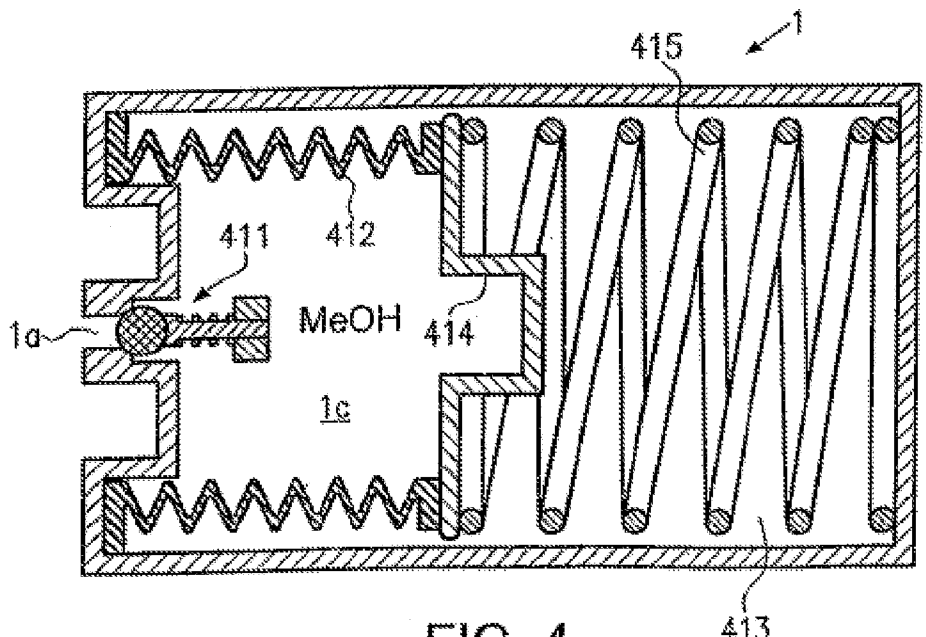
1
415
411
412
1a
MeOH
414
1c
413

FIG. 4

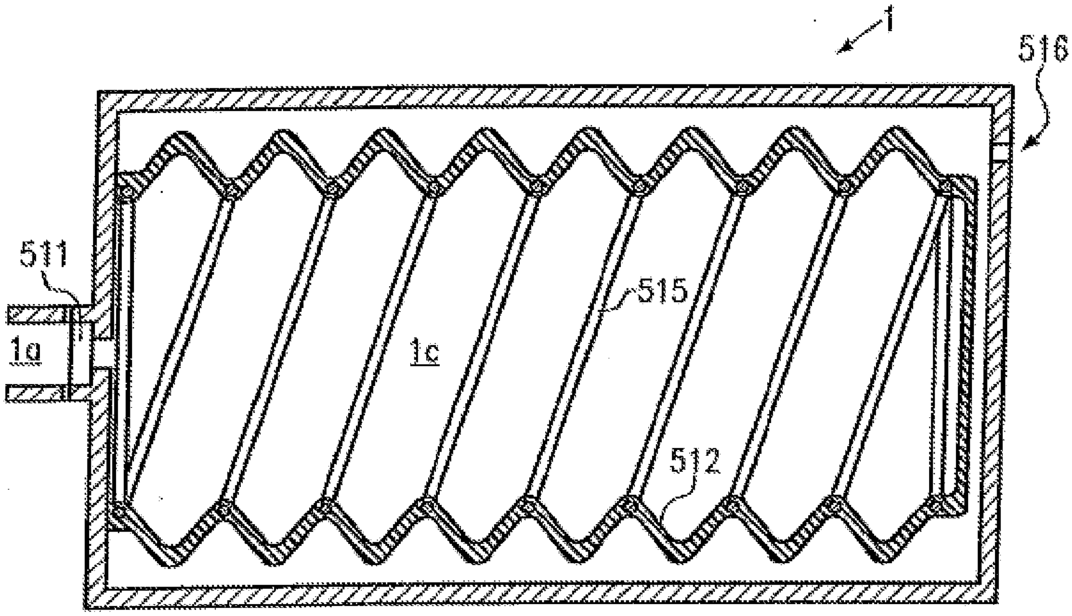

FIG. 5

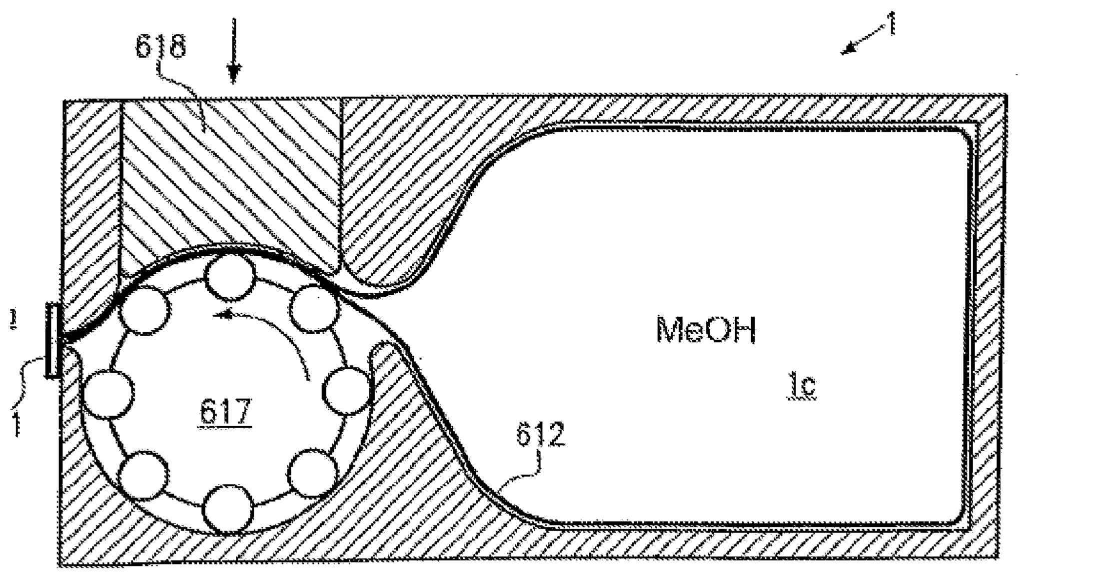

FIG. 6

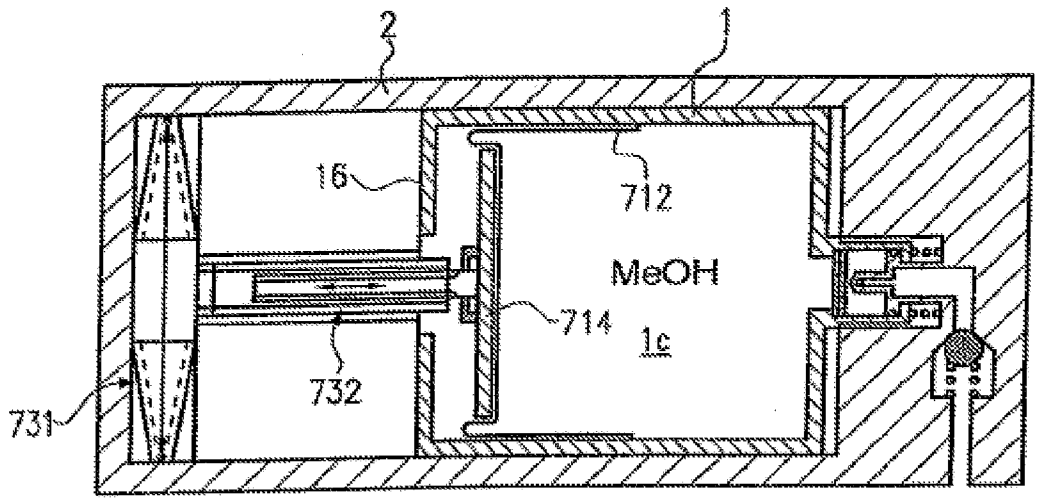

FIG. 7

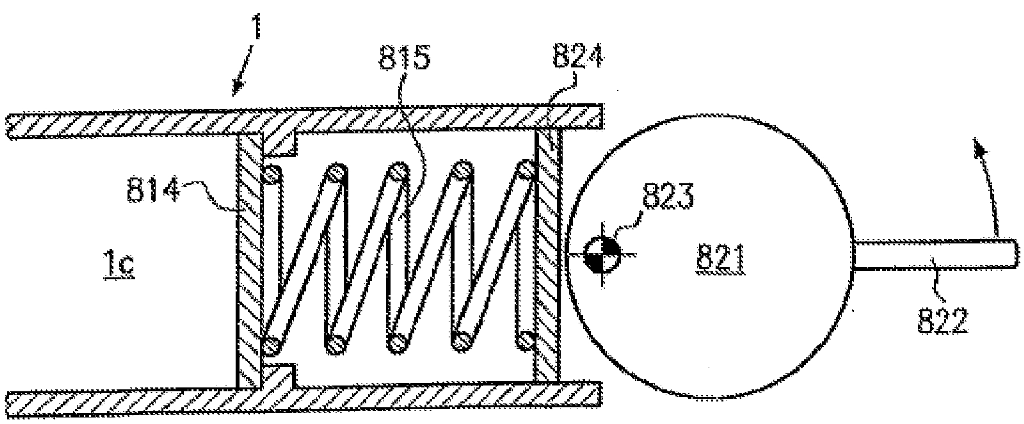

FIG. 8

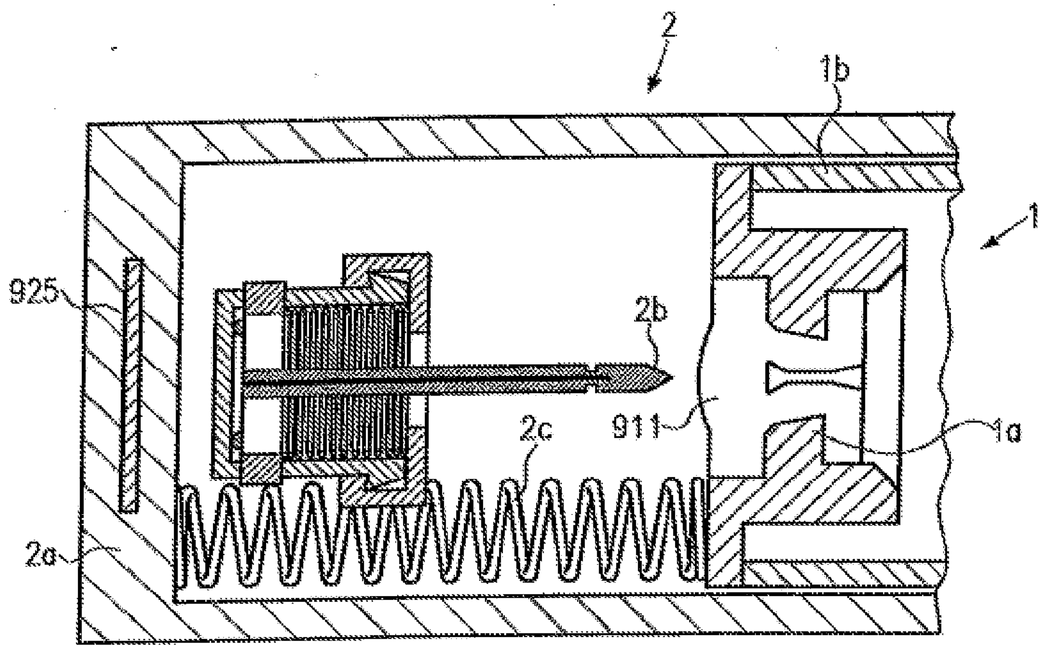

FIG.9A

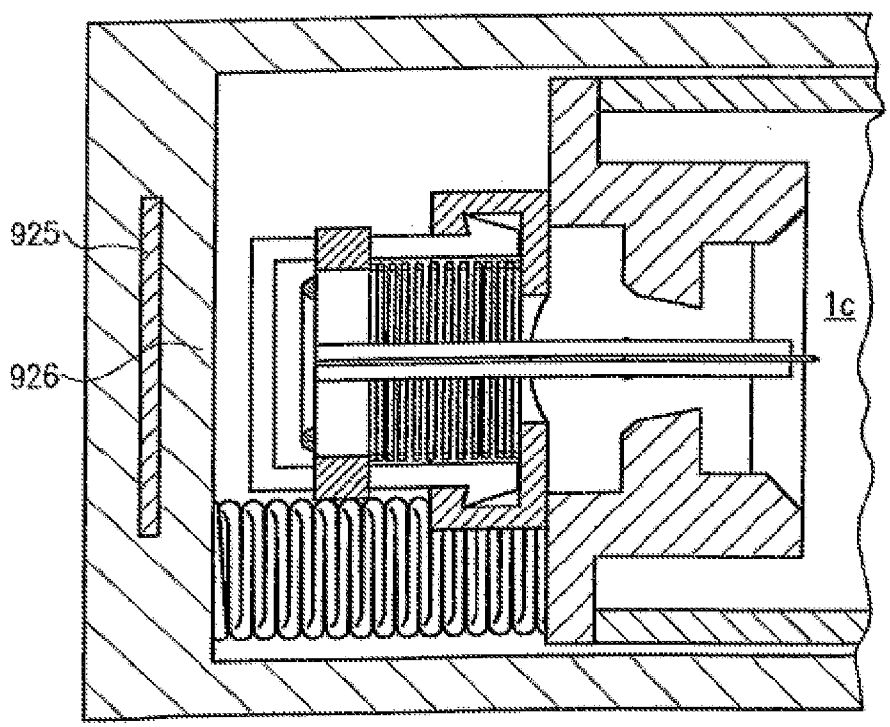

FIG.9B

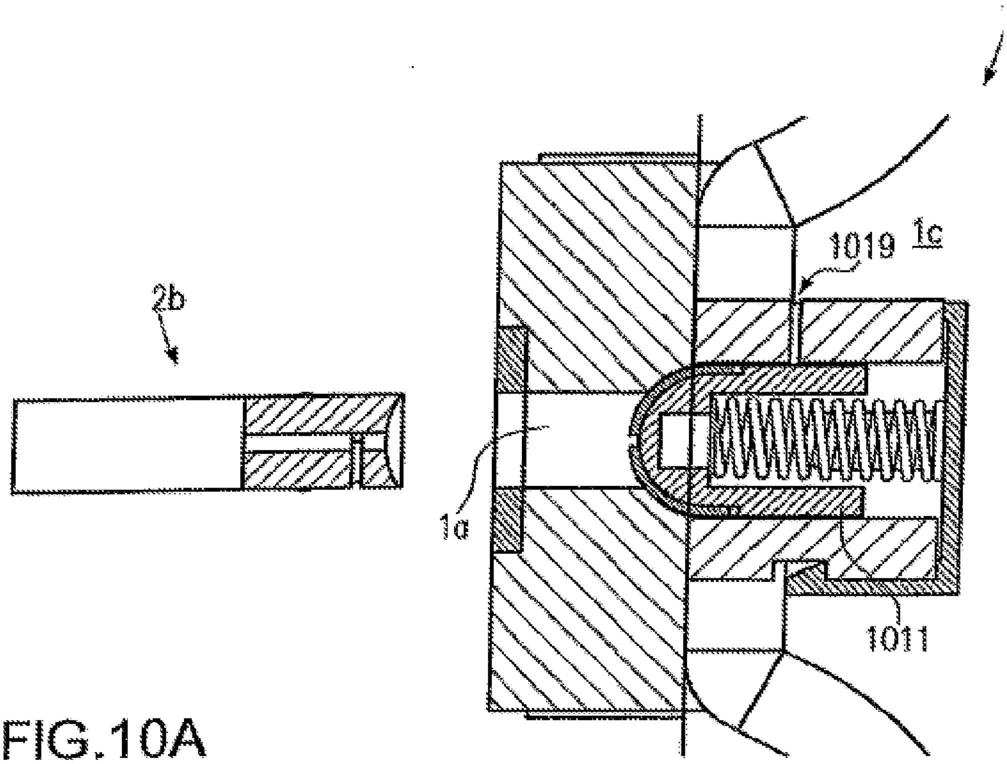

FIG.10A

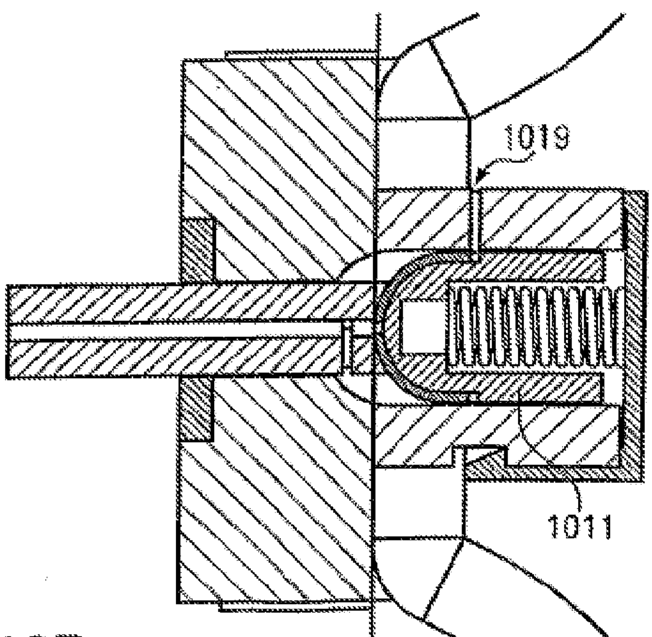

FIG.10B

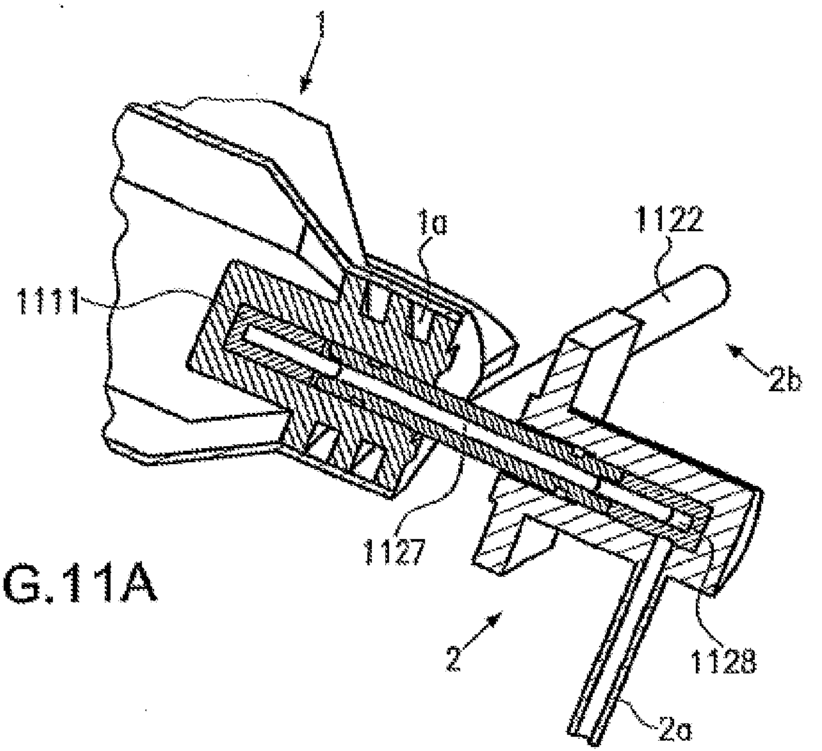

FIG.11A

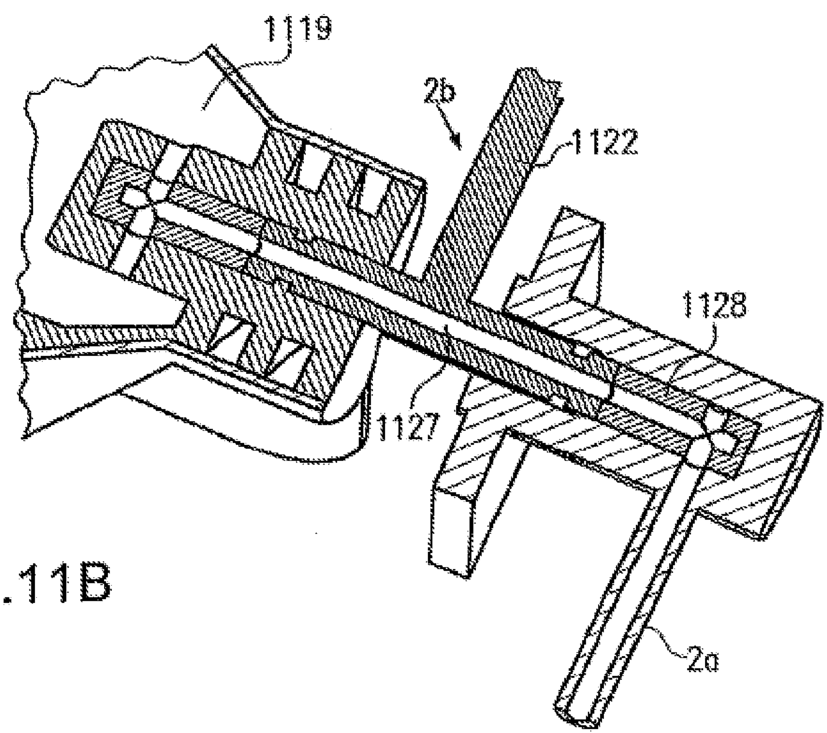

FIG.11B

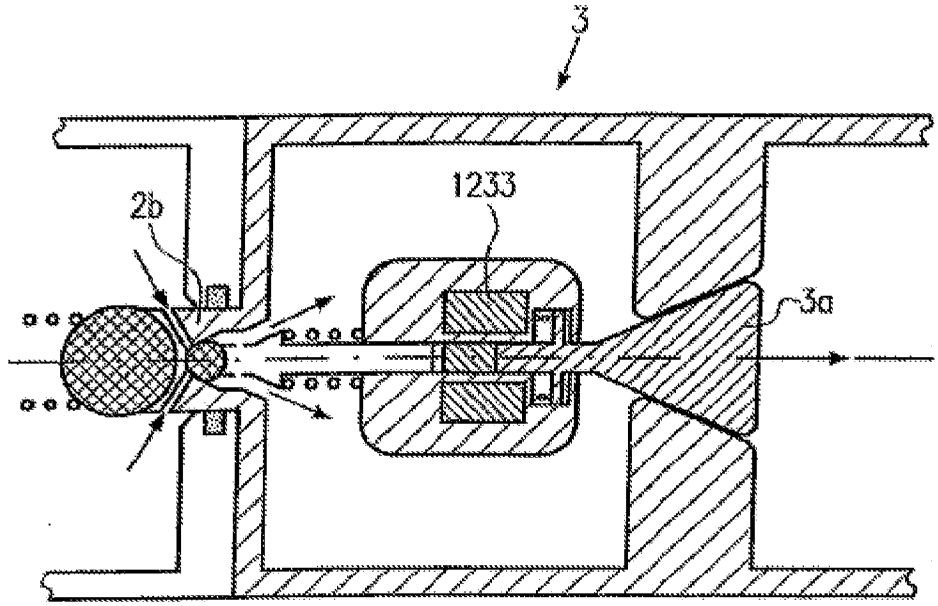

FIG.12

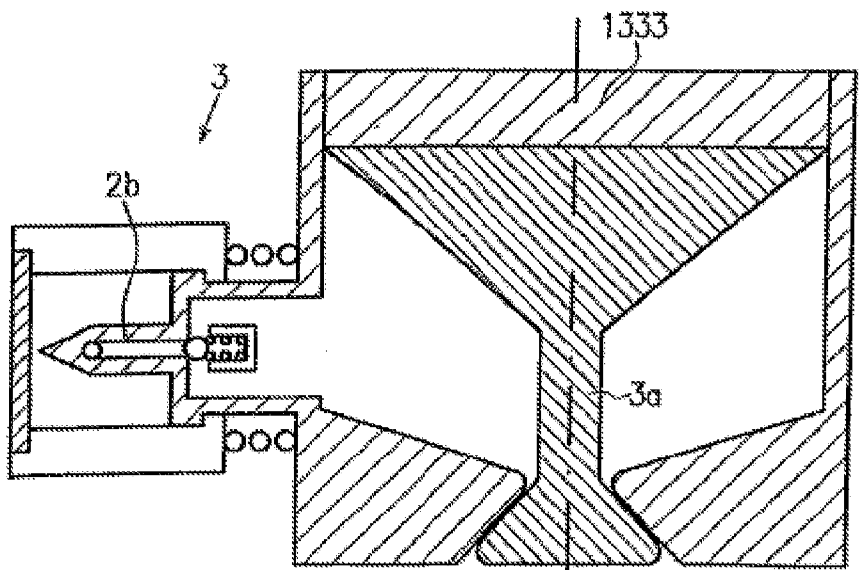

FIG.13

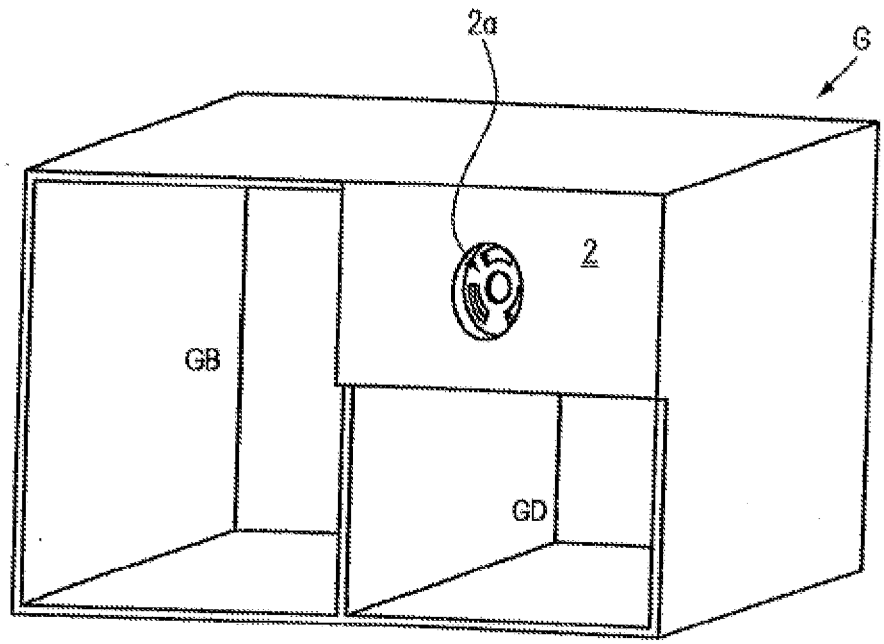

FIG.14A

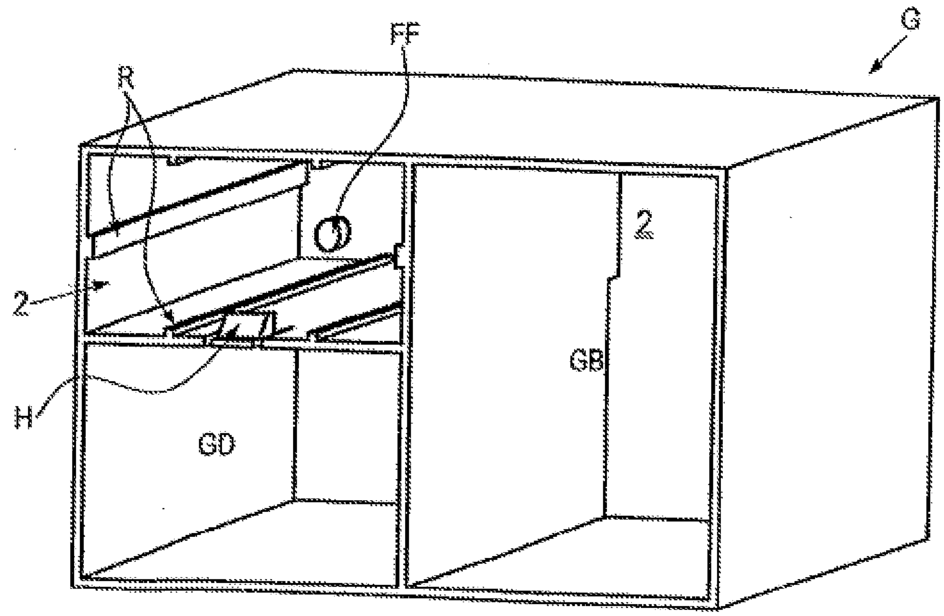

FIG.14B

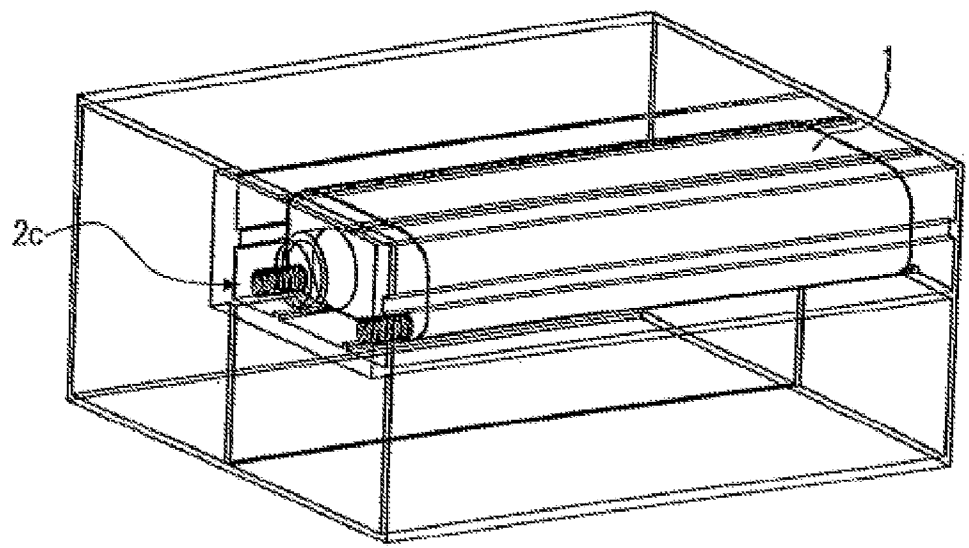

FIG.15